OBSERVATIONS ON THE GREAT LAKES.

REPORTS FROM VESSELS.

The Lake Marine Section of the Forecast Division has received reports from the captains of 73 vessels navigating the Great Lakes. The following miscellaneous items are extracted from their reports:

Capt. W. S. Hoag, steamship *Barge* **130**, 2d, western Lake Huron, northern lights from 8 p. m. to midnight. 9th, northeastern Lake Michigan, northern lights from 8 to 10.30 p. m.

Capt. George Holdridge, steamship *Barge* **132**, 9th, eastern end of Lake Superior, northern lights from 9.30 p. m. to midnight.

Capt. John Lowe, steamship *Kaliyuga*, 3d, southeastern Lake Superior, northern lights from 11 p. m. to past midnight.

Capt. R. J. Crowley, steamship *Roumania*, 9th, Lake Huron, between Detroit and Presque Isle, northern lights from 10 to 12 p. m.

Capt. F. A. Grans, steamship *Matoa*, 3d, Sault Ste. Marie, northern lights.

Capt. C. Petersen, steamship *Robert L. Fryer*, 4th, Lake Huron, northern lights from midnight to 2 a. m.

Capt. Thomas Hackett, steamship *Volunteer*, 3d, Lake Huron, northern lights.

Capt. Edward Mooney, steamship *Wa-Wa-Tam*, 9th, southern Lake Superior, northern lights from 8 p. m. to 8 a. m., 10th.

Capt. W. P. Robertson, steamship *Petoskey*, 9th, northeastern Lake Michigan, northern lights from 10 p. m. to 2 a. m., 10th.

Capt. R. Jollie, steamship *C. B. Lockwood*, 9th, St. Marys River, northern lights.

Capt. J. W. Morgan, steamship *Australasia*, 9th, Lake Superior, northern lights from 9.15 to 10.30 p. m.

REPORTS FROM U. S. LIFE-SAVING STATIONS.

Through the co-operation of the General Superintendent of the Life-Saving Service and the Secretary of the Treasury, the Weather Bureau has received monthly reports for the month of June from the keepers of 36 U. S. Life-Saving Stations on the Great Lakes.

SUNSHINE AND CLOUDINESS.

GENERAL REMARKS.

The quantity of sunshine, and therefore of heat, received by the atmosphere is a fundamental factor in meteorology; the quantity received by the atmosphere as a whole is very nearly constant from year to year, but the proportion received by the surface of the earth depends largely upon the distribution of cloudiness. The sunshine is now recorded automatically at about 38 regular stations of the Weather Bureau, either by its photographic or its thermal effects. The cloudiness is recorded by personal observations at all stations and is given in the column of "average cloudiness" in Table I.

SUNSHINE.

An instrumental record of sunshine has been kept during the month at 17 stations by means of the photographic sunshine recorder and at 21 stations by means of the thermometric sunshine recorder; the results of these observations are given in Table IV, for each hour of local mean time (not seventy-fifth meridian time). The stations recording the largest percentages of sunshine between the hours of 11 a. m. and 1 p. m. were: Columbus, Ohio, 95; Detroit, 92.5; Little Rock, 94.5; Louisville, 92.5; Memphis, 95.5; St. Louis, 97; Santa Fe, 94. The stations reporting the smallest percentages were: Portland, Oreg., 42; Eastport, 40.

The general average percentage of sunshine for the month is given in the next to the last column of Table IV. The highest percentages were: Tucson, 99; St. Louis, 91; Santa Fe, 88. The lowest percentages were: Eastport, 31; Portland, Oreg., 35.

CLOUDINESS.

The average cloudiness between sunrise and sunset, as based on numerous personal observations, is given for each Weather Bureau station in Table I; the complement of this average cloudiness gives the observer's estimated percentage of clear sky, and these latter numbers are given in the last column of Table IV.

COMPARISON OF SUNSHINE AND CLEAR SKY.

The sunshine registers give the duration of direct sunshine whence the percentage of possible sunshine is derived; the observer's personal estimates give the percentage of area of clear sky. It should not be assumed that these numbers should agree, and for comparative purposes they have been brought together, side by side, in the following table, from which it appears that, in general, the instrumental record of percentages of duration of sunshine is almost always larger than the observer's personal estimates of percentages of area of clear sky; the average excess for this month is 6 per cent for photographic records and 15 per cent for thermometric records:

Difference between instrumental and personal observations of sunshine.

Photographic stations.	Instrumental.	Personal.	Difference.	Thermometric stations.	Instrumental.	Personal.	Difference.
Tucson, Ariz	99	92	7	St. Louis, Mo	91	73	18
Santa Fe, N. Mex	88	81	7	Little Rock, Ark	80	61	19
Cincinnati, Ohio	79	57	22	Columbus, Ohio	78	56	22
Memphis, Tenn	79	80	— 1	Louisville, Ky	78	56	22
Dodge City, Kans	77	63	14	Colorado Springs, Colo.	74	61	13
Kansas City, Mo	77	67	10	Detroit, Mich	74	61	13
Denver, Colo	77	66	11	Philadelphia, Pa	73	55	18
Washington, D. C	74	69	5	Salt Lake City, Utah	72	58	14
Galveston, Tex	73	72	1	Chicago, Ill	71	58	13
Cleveland, Ohio	72	58	14	Vicksburg, Miss	69	65	4
Bismarck, N. Dak	71	67	4	Portland, Me	68	33	35
Savannah, Ga	64	56	8	Wilmington, N. C.	66	60	6
San Diego, Cal	64	74	—10	New Haven, Conn	65	48	17
San Francisco, Cal	62	56	6	Buffalo, N. Y	64	52	12
Helena, Mont	48	45	3	Boston, Mass	62	40	22
Portland, Oreg	35	31	4	Key West, Fla	61	33	28
Eastport, Me	31	29	2	New Orleans, La	58	59	— 1
				New York, N. Y	58	51	7
				Rochester, N. Y	50	51	— 1
				Baltimore, Md	.....	66	.....
				Des Moines, Iowa	.....	68	.....

NOTES BY THE EDITOR.

RECORD OF AURORAS AT WILLETS POINT, N. Y.

A record of the display of the aurora was maintained from February, 1870, to December, 1885, by the battalion of engineers at Willets Point, New York Harbor (lat. 40° 47′ 21″ N., long. 4h. 55m. 7s. W.). Three sentinel posts were guarded nightly by soldiers of the battalion, who remained on duty from sunset to sunrise, and each was required to report whether he had seen any auroral light during the night, and also whether the sky had been sufficiently clear to permit any aurora to be visible. The average of the reports of these

three independent observers is considered to be the record of the station for that night.

The details of the results of this important work were published annually in the printed general orders of the battalion and were rearranged by the present editor and reprinted for the years 1870 to 1880 as Appendix III in Professional Papers No. III of the U. S. Signal Service. The following summary of the complete aurora record for sixteen years has been compiled from data furnished by the Chief of Engineers:

TABLE 1.—*Auroras and clear nights observed at Willetts Point, N. Y.*

Year.	January.		February.		March.		April.		May.		June.	
	A.	C.	A.	C.	A.	C.	A.	C.	A.	C.	A.	C.
1870	.....	.....	1.0	16.2	3.7	16.5	3.7	15.2	1.3	14.8	2.0	15.8
1871	2.5	15.0	1.0	14.5	9.0	14.0	9.0	18.0	10.5	19.5	5.5	17.0
1872	2.5	21.0	4.0	21.0	2.5	18.0	6.0	19.5	5.5	25.5	6.0	16.0
1873	6.3	16.0	8.3	22.0	7.7	18.0	5.7	15.6	2.6	16.0	6.7	20.6
1874	2.0	13.7	2.0	13.7	1.3	18.0	2.3	10.7	0.3	19.3	0.3	13.3
1875	0.4	17.2	2.5	16.2	1.5	13.8	1.5	13.0	2.5	16.2	0.0	16.2
1876	0.0	16.3	2.0	15.3	1.3	18.4	0.0	19.3	0.3	15.7	0.0	17.3
1877	0.0	19.3	0.0	18.7	1.3	12.3	2.3	12.6	2.0	15.0	0.0	16.3
1878	1.0	15.7	0.0	15.0	0.0	14.0	0.0	10.6	0.0	18.0	0.3	15.5
1879	0.0	19.0	0.6	16.7	0.0	16.7	1.3	15.0	1.6	18.7	3.0	17.3
1880	0.0	14.7	0.0	17.3	1.3	16.3	1.3	18.0	0.3	18.7	0.0	19.3
1881	0.0	18.7	2.3	15.3	0.0	13.3	2.7	18.0	2.3	14.3	0.7	13.0
1882	3.0	14.7	3.3	17.0	4.0	18.3	10.0	19.0	2.0	13.0	6.0	21.7
1883	0.0	10.0	2.3	15.3	3.3	22.0	2.7	15.3	0.3	16.7	1.0	17.0
1884	1.3	12.7	2.0	8.3	1.6	12.3	0.3	12.7	0.0	17.7	0.0	18.3
1885	0.0	14.7	1.7	14.7	0.0	14.0	0.3	18.0	3.3	14.0	1.7	21.0

Year.	July.		August.		September.		October.		November.		December.	
	A.	C.	A.	C.	A.	C.	A.	C.	A.	C.	A.	C.
1870	1.7	19.8	5.7	19.2	10.3	17.2	7.7	16.5	6.7	19.5	6.3	13.5
1871	6.5	20.0	2.5	22.5	3.0	20.5	2.5	20.0	5.5	17.5	2.0	12.5
1872	5.0	20.0	7.0	20.5	5.0	15.0	7.5	17.5	4.5	21.0	4.5	19.0
1873	6.3	16.3	4.0	15.0	3.7	17.0	1.7	19.7	0.7	17.7	0.3	19.7
1874	1.3	15.0	1.3	19.3	1.7	15.3	4.0	16.0	1.3	21.3	0.0	14.0
1875	0.4	16.2	0.0	16.0	2.5	21.5	0.7	16.7	1.5	15.5	0.0	10.2
1876	0.0	16.3	0.0	20.0	2.0	11.7	2.7	17.0	1.0	11.0	0.0	16.3
1877	0.3	13.7	0.0	16.6	0.0	18.0	0.3	15.3	1.0	15.0	0.0	18.0
1878	0.0	15.3	0.0	14.7	0.0	17.7	0.0	19.0	0.6	15.0	0.0	14.7
1879	1.0	16.3	0.0	15.0	1.3	22.3	0.0	21.3	0.0	15.0	0.0	10.7
1880	1.0	18.3	3.0	18.0	1.0	18.3	2.0	20.7	3.0	16.0	0.0	20.0
1881	2.7	14.3	0.0	17.3	4.0	18.7	2.0	17.7	1.7	15.7	4.7	14.7
1882	3.3	18.3	6.3	21.0	1.3	12.0	5.0	12.7	7.3	17.0	3.3	16.0
1883	5.3	21.7	1.3	26.3	3.3	16.0	2.3	18.3	2.0	18.7	0.3	17.7
1884	0.0	15.3	0.0	15.7	3.0	22.7	1.3	15.7	1.3	17.7	1.3	11.3
1885	0.7	20.3	0.7	15.7	1.3	22.7	0.7	20.0	0.3	15.0	0.c	17.7

Table 1 shows for each month, and for the year, the number of auroras in column A and the number of clear nights in column C; the decimal fractions result from the fact that each datum is the average of the records of the three sentinels; the differences between the reports of individual sentinels can be investigated by referring to the tables published in the printed orders of the battalion and generally republished in the annual reports of the Chief of Engineers; these differences are probably to a slight extent personal, but often also are due to the uncertainty as to whether certain faint lights were of an auroral nature or not. The peculiar value of this series consists in three features: (1) the continued presence of three observers on every night throughout the whole series; (2) the continuous examination of the entire visible sky throughout the whole night; (3) the record of nights that were clear enough to see an aurora if present. There are but few series of auroral observations in which this third feature has been properly attended to, and I suppose that there is no other series in which the first and second features have been maintained for so long a number of years. In comparing the records for different localities and years, it has, ordinarily, been necessary to assume that the number of clear nights averaged about the same at the different stations, and that, therefore, the number of observed auroras indicated the relative frequency, without any further correction. It has also sometimes been considered proper to deduce the total number of theoretically possible auroras for the whole year by assuming that the same proportion of auroras would have been visible during cloudy nights as has actually been observed on clear nights. This assumption, however, implies that the aurora has little or nothing to do with the clouds, that it exists in the upper atmosphere quite independent of the lower clouds, and that the latter simply hide it from view. If there were no causal relation between the aurora and the cloud, the above assumption would be valid, and the computed total number of possible auroras could be used as an index of auroral frequency. But it is far better to avoid this assumption, which we may do by dividing the number of observed auroras by the number of clear nights on which they could have been seen, if present; the quotient expressed as a percentage will then simply state an observed fact, uncomplicated with any hypothesis, viz, that auroras were actually observed on the given percentage of clear nights.

TABLE 2.—*Secular period of auroral frequency.*

Year.	No. of clear nights observed.	No. of clear nights with auroras.	Auroral frequency, per cent.	No. of cloudy nights.	Possible auroras on cloudy nights.	Sum of observed plus possible.
1870	184.2*	50.1*	27.2*	150*	49†	99
1871	211.0	59.5	28.2	154	44	104
1872	234.0	66.0	25.6	132	34	94
1873	213.6	54.0	25.3	151	38	92
1874	189.6	17.5	9.2	175	17	35
1875	188.7	13.5	7.2	178	13	27
1876	194.6	9.3	4.8	171	8	17
1877	190.8	7.2	3.8	174	6	13
1878	185.0	1.9	1.0	180	2	4
1879	204.0	8.8	4.3	161	7	10
1880	215.6	12.9	6.0	150	9	22
1881	191.0	23.1	12.1	174	21	44
1882	201.0	55.0	27.4	164	44	99
1883	215.0	24.1	11.2	150	17	41
1884	180.3	12.1	6.7	186	12	24
1885	207.8	10.7	5.2	157	8	19

* During 11 months.
† This figure is obtained by assuming that during the 150 cloudy nights and the 31 days of January, 1870, when no observations were attempted, auroras were as frequent as during the 184 clear nights on which 50 were observed.

TABLE 3.—*Annual period of auroral frequency during the* 16 *years,* 1870 *to* 1885, *inclusive.*

Month.	No. of clear nights observed.	No. of clear nights with auroras.	Auroral frequency, per cent.	No. of cloudy nights.	Possible auroras on cloudy nights.	Sum of observed plus possible.
January	238.7*	19.0*	8.0*	226.3*	20.5†	39.5
February	257.2	33.0	12.8	194.8	24.9	57.9
March	255.9	38.5	15.0	240.1	36.0	74.5
April	250.5	49.1	19.6	229.5	45.0	94.1
May	273.1	34.8	12.7	222.9	28.3	63.1
June	275.6	33.2	12.0	204.4	24.5	57.7
July	277.1	35.5	12.8	218.9	28.0	63.5
August	292.8	31.8	10.9	203.2	22.1	53.9
September	286.6	43.4	15.1	193.4	29.2	72.6
October	284.1	40.4	14.2	211.9	30.0	70.4
November	268.6	38.4	14.3	211.4	30.2	68.6
December	246.0	22.7	9.2	250.0	23.0	45.7

* During 15 years.
† This figure is obtained by assuming that during the 31 days of January, 1870, auroras were as frequent as during the 238.7 clear nights of the remaining Januarys; the 2.5 auroras thus hypothecated are added to the other 18 auroras hypothecated for the 226 cloudy nights.

Tables 2 and 3 show the numbers of clear nights and auroras for the respective years, and also for the respective months, at Willetts Point, and for comparative purposes there are given both forms of computation, in parallel colums, viz, (1) the percentages of auroral nights; (2) the sum total of observed and possible auroras. The reader will see that there is sometimes an appreciable difference between these two modes of computation; the former is always preferable as involving no hypothesis.

In general it will be seen that the secular period of the auroral frequency parallel to that of the sun spots is well

marked. In the annual period it will be seen that the months of greatest frequency are those of the equinoxes, viz, April and September, and the months of least frequency are December and January, corresponding exactly to a well-known generalization first announced by Mairan and modified by Lovering, but explained by Mr. E. B. Elliott, of Washington, in 1872 (Bull. Phil. Soc., Vol. 1, p. 45), according to whom the number of auroras depends on the rate at which the earth, in its annual orbit, cuts through cosmic lines of electric force.

DISCHARGE OF STREAMS DURING FLOODS.

This Bureau has received from John E. Codman, of the Bureau of Water Supply, Philadelphia, copies of the automatic records of the rain gauges for three different localities in Pennsylvania, about 35 miles apart, viz: (1) corner of Thirty-second and Spruce streets, Philadelphia; (2) the Forks of the Neshaminy; (3) Frederick Post-office, Spring Mount. These show the total amount and the rate of rainfall during the ten days, May 19–28, 1894; the maximum rate during several hours was 2.04 inches per hour at station No. 1; 1.03 at station No. 2; and 2.90 at station No. 3. These stations are in the watershed of streams that flow into the Schuylkill River. The registering stream gauge in the Perkiomen showed a maximum rise of 17 feet, and a discharge for about two hours at the rate of 100 cubic feet per second for each of its 152 square miles of watershed. The Neshaminy stream gauge showed a rise of 16.3 feet and a discharge for two hours of about 100 cubic feet per second for each of its 139.3 square miles of watershed. The Yohickon guage showed a rise of 13.2 feet, and a flow for about two hours of 100, or a little more, cubic feet per second for each of its 102.2 square miles of watershed. These are greater discharges than any that have been recorded within the past ten years or since the records began, although it is stated that these streams were two or three feet higher in 1869.

OBSERVATIONS AT HONOLULU, HAWAIIAN ISLANDS.

As the weather on the Pacific coast depends so largely upon the conditions of the atmosphere to the westward, it is considered important to publish in full and as soon as practicable the data furnished by observers in Alaska, the Hawaiian Islands, and adjacent regions.

Meteorological observations at Honolulu, Hawaiian Islands, for June, 1894, by Curtis J. Lyons, Meteorologist to the Government Survey.

Date.	Barometer at sea level. 9 a. m.	3 p. m.	9 p. m.	Temperature. 6 a. m.	2 p. m.	9 p. m.	Minimum.	Maximum.	Humidity. Relative. 9 a.m.	9 p.m.	Absolute.	Wind. Direction.	Force.	Cirrus cloud moving from—	Rain to 6 a. m.
	Ins.	*Ins.*	*Ins.*	°	°	°	°	°	%	%					*Ins.*
1 ..	30.18	30.10	30.17	73	79	74	73	83	63	78	6.8	ne.	4, 5,	.....	0.00
2 ..	30.15	30.09	30.13	72	78	74	70	80	71	67	6.6	nne.	3	.....	0.12
3 ..	30.12	29.97	30.13	73	79	74	70	81	59	67	6.1	ne.	4	.....	0.15
4 ..	30.13	30.07	30.14	74	80	74	73	82	53	67	5.7	ene.	5, 3	.....	0.00
5 ..	30.11	30.07	30.15	73	79	74	72	81	64	70	6.3	ene.	3	.....	0.00
6 ..	30.14	29.98	30.12	67	81	73	67	83	60	69	6.3	ne.	3	W.	0.00
7 ..	30.13	30.06	30.12	73	82	73	66	82	60	74	6.6	e.	3	.....	0.00
8 ..	30.12	30.05	30.14	66	80	70	65	82	67	85	6.6	n., s.	1	s.	0.00
9 ..	30.10	30.06	30.13	70	80	71	66	86	70	83	6.8	s., e.	1, 3, 0	s. 30 w.	0.00
10 ..	30.10	30.02	30.08	68	80	74	66	83	70	74	7.1	s., ne.	2	.....	0.00
11 ..	30.08	30.02	30.08	74	80	75	72	82	61	64	6.6	ne.	3	n. 40 w.	0.00
12 ..	30.10	30.06	30.14	74	78	75	73	81	63	71	6.6	ne.	3, 6	.....	0.00
13 ..	30.15	30.12	30.13	74	79	74	72	80	00	66	6.2	ene.	6, 7	.....	0.01
14 ..	30.19	30.12	30.10	73	76	73	73	80	70	74	6.3	ene.	5	.....	0.01
15 ..	30.13	30.03	30.10	70	77	72	68	80	70	70	6.1	nne.	4	.....	0.16
16 ..	30.09	30.02	30.07	72	79	73	69	81	62	66	6.0	ne.	4	.....	0.09
17 ..	30.07	30.01	30.07	70	79	72	69	82	56	70	6.1	ne.	3	.....	0.00
18 ..	30.09	30.05	30.14	66	79	73	66	82	66	73	6.3	n, w., ne.	2	s. 80 w.	0.00
19 ..	30.15	30.09	30.16	72	75	75	71	83	60	70	6.6	ne.	3	s. 70 w.	0.01
20 ..	30.16	30.08	30.14	72	79	73	72	82	74	80	7.1	ne.	3, 5	.....	0.01
21 ..	30.14	30.07	30.12	72	78	72	71	82	66	80	6.8	ne.	4	.....	0.16
22 ..	30.13	30.09	30.18	72	80	74	71	81	67	74	6.8	ne.	4	.....	0.07
23 ..	30.18	30.12	30.18	73	81	74	72	83	67	67	6.5	ne.	4	.....	0.02
24 ..	30.17	30.12	30.15	73	80	75	70	83	60	70	6.6	ne.	4	s. 75 w.	0.05
25 ..	30.16	30.12	30.16	73	80	74	72	82	64	66	6.5	ne.	4	.....	0.04
26 ..	30.17	30.13	30.20	73	80	75	71	82	69	66	6.2	ne.	4	.....	0.01
27 ..	30.21	30.14	30.20	74	78	75	73	81	58	66	6.1	ene.	5	s. 45 w.	0.00
28 ..	30.19	30.13	30.19	73	79	73	72	80	05	74	6.2	ne.	5	s.	0.00
29 ..	30.19	30.13	30.19	72	78	74	70	80	74	70	6.6	ne.	5	.....	0.03
30 ..	30.16	30.09	30.13	72	78	74	69	80	74	65	6.2	ne.	4	.....	0.14
Mean.	30.140	30.085	30.140	71.8	79.4	73.5	70.1	81.7			6.4				0.98
	30.112			74.9											

The barometer is corrected for temperature and reduced to sea level, but the gravity correction, —0.06, is still to be applied.

The absolute humidity is expressed in grains of water, per cubic foot, and is the average of four observations daily.

The rain is measured at 6 a. m., daily.

The extremes of the force of the wind are given when it has varied more than usual. 4th, very dry air. 8th, convectional pillars of clouds. 10th, spiral whirl of lower clouds. 14th, light earthquake on Hawaii. 19th, lower clouds from east. 28th, disturbance.

For the month of June pressure was .04 above normal; temperature 1.5° below normal; humidity and rainfall low.

METEOROLOGICAL TABLES.

[*Prepared by the Division of Records and Meteorological Data.*]

The following pages present in tabular form the climatological data for the current month, on which the text of the preceding part of this REVIEW has, to a large extent, been based.

For a detailed description of the methods of observation, compilation, and computation relating to these tables, the reader is referred to page 129 of the MONTHLY WEATHER REVIEW for March, 1894. The general contents of the tables are as follows:

Table I gives for 140 Weather Bureau stations, making two observations daily, and for 10 others making only one observation, the ordinary climatological data.

Table II gives for about 2,200 stations, occupied by voluntary observers, the mean and extreme temperatures and the total precipitation.

Table III gives climatological data for about 30 Canadian stations.

Table IV *a* gives for 38 Weather Bureau stations the percentages of sunshine for each hour of local mean time.

Table IV *b* gives for 43 Weather Bureau stations the total hourly rainfall for each hour of seventy-fifth meridian time.

Table V gives for 81 stations the mean temperatures for each hour of seventy-fifth meridian time.

Table VI gives for 66 stations the mean pressures for each hour of seventy-fifth meridian time.

Table VII gives for 138 stations the mean hourly movement of the wind.

Table VIII gives for 68 stations the resultant movements and directions of the wind from continuous registrations.

Table IX gives for 140 stations the component and resultant directions based on simultaneous observations at 8 a. m. and 8 p. m., seventy-fifth meridian time.